A Lifeline for the Weakest Link?

Financial Contagion and Network Design

BY YARON LEITNER

Links between firms, individuals, or countries are more common in this age of computers and global interdependence. While such links benefit participants, a tightly interconnected marketplace also has a downside: Problems at one firm can be quickly transmitted to others in a process economists call contagion. The possibility of contagion has led many people to worry about excessive linkages among financial institutions. In this article, Yaron Leitner describes how contagion can occur, explains why the threat of contagion is not necessarily a bad thing, and shows why some firms may choose to bail out other firms that are facing financial problems.

In the normal course of business dealings, banks, commercial firms, individuals, and even countries become interlinked in many ways. For example, banks enter financial contracts (such as interest rate swaps and forward contracts) with one another, individuals invest in the same stock, or firms provide credit to one another.

While everyone in the examples above clearly benefits from such linkages — otherwise, they wouldn't have entered into contracts in the first place — there is a downside to a tightly interconnected marketplace. Problems at one firm can be quickly transmitted to others in a process economists call contagion.

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The negative effects of contagion have led many people to worry about "excessive" linkages among financial institutions. Whether this concern is valid is an open question.

In this article, I will discuss some examples of the ways in which linkages can lead to contagion. Interestingly, these linkages may also lead to private-sector bailouts where one firm is rescued by other firms linked to it to prevent the spread of crisis. Webster's dictionary defines "bailout" as a "rescue from financial distress." Usually this word carries negative connotations because people associate financial distress with the misbehavior of firms' managers and assume that the bailout will require taxpayers' funds. But financial distress can also occur as a result of bad luck, and bailouts (for example, the ones discussed in this paper) need not necessarily involve public money. Therefore, in this article I will use the word bailout without any pre-judgment. In particular, I will show that interdependence may improve *private* incentives to provide insurance in the form of private-sector bailouts and that this may sometimes be beneficial both to individuals and to society as a whole.

I will also explain why the *threat* of contagion is not necessarily a bad thing and examine some of the tradeoffs involved in the design of a financial network. One benefit of understanding these tradeoffs is that we can then attempt to answer questions such as whether financial institutions should be closely interlinked or how many institutions should belong to a particular financial network.

HOW CAN FINANCIAL CONTAGION OCCUR?

A necessary ingredient for contagion is some sort of linkage among firms (or investors). For example, suppose that I plan to pay you next month out of the money that I receive from Dan. But what if Dan gets into financial trouble and can't pay me back? In other words, what if Dan defaults? I will not have the money to pay you, so I will default as well. What's more, if lots of people were linked in this way, Dan's default could trigger not only my

default but also your default and the defaults of many others in a domino effect.

Researchers have studied several examples of financial contagion.

Trade Credit. In a 1997 working paper, Nobuhiro Kiyotaki and John Moore took the idea in the example above a bit further. In their model, firms form links by giving trade credit to one another. In other words, firms that supply goods to other firms agree to receive payments upon the delivery of those goods (and not when the order is made). In addition to illustrating how such linkages may lead to contagion, Kiyotaki and Moore also showed that flexibility in carrying out agreements does not necessarily promote stability.

To understand how their model works, consider the following: There are three firms: Mandark Time Dilators, Tom Swift Encyclotronics, and Dexter Lab Supplies (Figure 1). Mandark ordered 100 units of encyclotrons from Tom Swift. Mandark needs these encyclotrons to produce time dilators, so it is willing to pay $1 per unit. Other firms don't value encyclotrons as much, so they will pay only 50 cents per unit. Mandark does not have cash today (when the order is placed), but it plans to have the cash next month when the goods are delivered. Thus, the contract calls for payment upon delivery.

Swift, in turn, ordered 100 units of special tubes from Dexter. As before, Swift needs these tubes for its production process. Swift agrees to pay $1 per tube, and payment is due next month upon delivery. However, Swift does not plan to have any cash of its own next month. It intends to use the $100 receivable from Mandark to pay Dexter.

This arrangement usually works well, but in some cases, it doesn't. Suppose, for example, that when we reach the delivery date, Mandark finds out that it has a temporary liquidity problem — its profits turned out to be lower than expected (after an eclipse of the sun caused some unexpected delays in the production of time dilators); therefore, it has only $60 rather than the anticipated $100. Suppose further that the three firms aren't well enough known to be able to borrow against future revenues. In other words, Mandark cannot raise more money from a bank today to pay Swift, according to their initial agreement. Thus, it can buy only 60 units, for a total of $60. This means that Swift is left with 40 units of encyclotrons.

Swift has two options. The first is to keep the undelivered units and wait until Mandark has the money (say, in three weeks). Then it will sell the 40 units at $1 per unit. The second option is to "liquidate" the remaining 40 units, that is, sell them to another firm at a low price of 50 cents per unit, for a total of $20.

If Swift chooses the first option, it will have $60 (rather than the anticipated $100) to pay Dexter; hence, it will buy only 60 tubes, for a total of $60 (Figure 2). If Swift chooses the second option, it will have $80 today — $60 receivable from Mandark and $20 from liquidation of the remaining units. Consequently, it will buy 80 units from Dexter, for a total of $80 (Figure 3). In both cases, Dexter will receive less than the $100 it was supposed to get, so it may develop a liquidity problem as well. In other words, Mandark's financial problem can trigger financial problems at both Swift and Dexter. If many firms are linked in this way, a problem that originates in Mandark can spread to many firms in a contagious fashion.

But comparing Figures 2 and 3 illustrates another interesting point: You might think that flexibility in carrying out agreements — in our case Swift's giving Mandark some extra time to make payments — would promote stability. But in our example, the opposite is true. If Swift chooses to liquidate rather than reschedule Mandark's payments, Mandark's initial problem will have smaller effects on the whole chain of firms because Swift could buy 80 units from Dexter rather than only 60.[1] Of course, if all firms could postpone payments, no problem would arise. But it may be the case that

[1] If there were more firms linked in this way and each firm liquidated the undelivered units, Dexter could buy 90 units from its supplier, for a total of $90; Dexter's supplier could buy 95 units from its supplier for a total of $95; and so on. Eventually, firms could buy almost all of the goods they initially ordered.

FIGURE 1

Payments on Scheduled Delivery Date per Initial Agreement

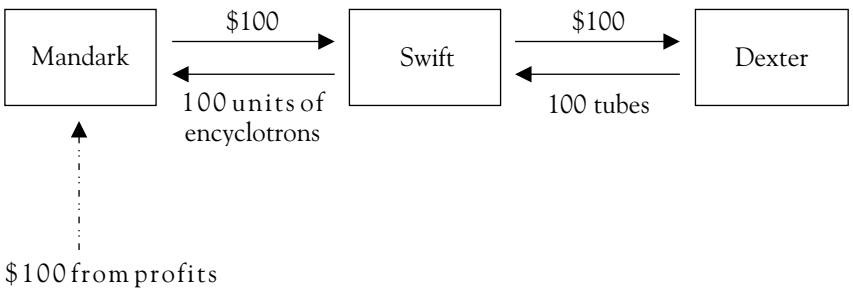


FIGURE 2

Payments on Scheduled Delivery Date If Swift Reschedules Payment for Remaining Units

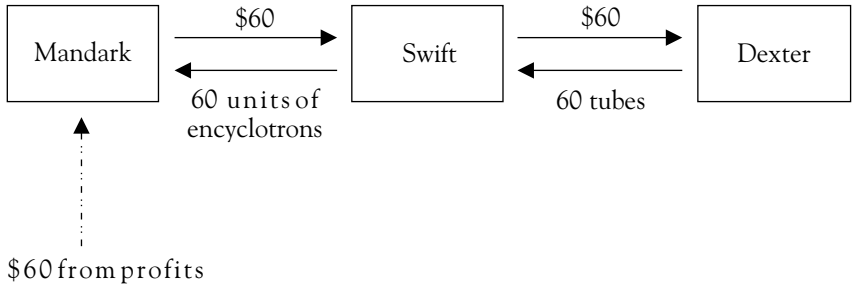
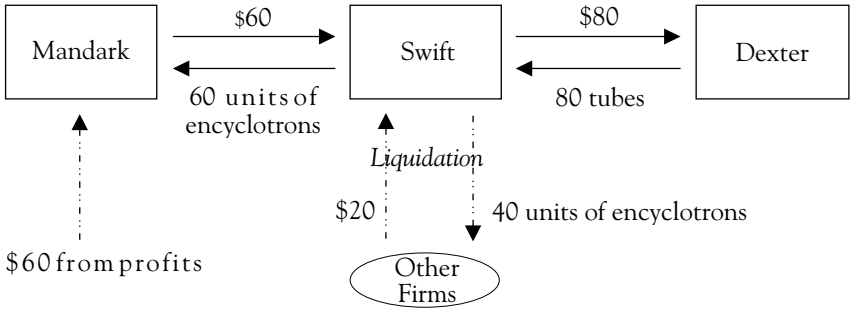


FIGURE 3

Payments on Scheduled Delivery Date If Swift Liquidates Remaining Units



some firms along the chain must have the cash (or most of it) today or that the cost of postponing payments is too high for some firms. If this is the case, rescheduling payments may not be good for the entire group of firms (or, more generally, for the economy as a whole), although it may be privately beneficial for Mandark and Swift.

Interbank Deposits. The article by Franklin Allen and Douglas Gale demonstrates that linkages among banks can also lead to contagion. Banks often hold deposits with each other to facilitate the clearing of checks and other payments. Suppose, for example, that Janeway Bancorp holds some deposits in Picard Bancorp. When Picard has liquidity problems because a number of borrowers are temporarily unable to make loan payments, its depositors may become worried about its financial strength and its ability to honor agreements. In extreme cases, they may all panic and "run" to the bank to withdraw their money. Of course, the bank does not have enough cash for everyone. It can attempt to raise more cash by selling assets or calling in loans early, but if it does so, the bank will receive less than full return. Thus, the bank may not be able to raise enough money to pay all of its depositors, so it goes bankrupt, that is, it is closed by its regulator.

How does Picard's bankruptcy affect Janeway? Janeway Bancorp has many assets, some of which are the deposits it holds with Picard. But if Picard goes bankrupt, its uninsured deposits may lose most of their value. Therefore, Janeway may see a significant decline in the value of its assets. Like Picard's depositors, Janeway's depositors may also become worried and run to withdraw their deposits, thereby creating a liquidity problem for Janeway. If this liquidity problem is very severe, Janeway may go bankrupt and have to be closed as well. More generally, if many banks are linked to one another, the initial crisis at Picard Bancorp may spread to other banks.

Changes in Investors' Wealth. Consider another example of contagion. When I invest my money in a stock issued by AlphaBeta Corporation, I am essentially linked to all other investors who buy that stock. If some of these investors also have XYZ Corporation's stock in their portfolios, I may become exposed to changes in the price of XYZ, even though I do not hold that stock directly in my portfolio.

> If many banks are linked to one another, the initial crisis at [one bank] may spread to other banks.

To see why, suppose that the price of XYZ declines because of some change in that company's expected profits. Investors who hold XYZ's stock in their portfolios lose money — their total wealth declines. As a result, they may become more careful with their

remaining money. Rather than investing it in the stock market, they may decide to invest in safer assets such as Treasury bills. Or maybe they'll just put their money in savings accounts in a bank. Thus, they may choose to sell XYZ's as well as other stocks they currently hold, for example, AlphaBeta's. This type of behavior may lead to a decline in the price of AlphaBeta's stock.[2] In other words, the contagion may spread from one stock to another.[3]

Note that the argument above does not require that the two firms, AlphaBeta and XYZ, be in the same industry. If this were the case, prices of these two stocks could rise or fall together simply because the two firms are similar. Thus, one important insight is that contagion may reduce the benefits of portfolio diversification.[4]

Another scenario in which changes in wealth can trigger contagion is when a firm needs to post collateral in order to borrow. Realizing that firms don't always pay back loans, lenders usually require collateral. For example, when a firm borrows in order to expand, it has to post its physical assets (for example, plant and equipment) as collateral to secure the loan. However, in an economic downturn, the value of that collateral might fall, even when the borrowing firm is doing well. Why? If other firms are doing poorly and their demand for new equipment decreases, this decline in demand will cause prices for all equipment to fall, including the items posted as collateral. Since the value of the borrower's collateral has gone down, it might not be able to borrow as much as it originally planned, and it may not be able to expand by buying additional equipment. This, in turn, can translate into an even stronger decline in prices affecting even more firms.[5]

THE DESIGN OF FINANCIAL NETWORKS: COMMITMENT VS. SYSTEM FAILURE

All the examples in the previous section describe *financial networks*, a term that refers to the ways in which banks, firms, and investors are linked to one another through financial commitments or financial markets.

Networks can arise in different ways. Regulators often make rules that affect the extent to which financial institutions or investors are exposed to one another's problems. These rules can indirectly affect which types of networks develop. For example, by imposing restrictions on cross-border trade, regulators can make some links infeasible, thus preventing the spread of contagion from one country to another. Regulators can also set margin requirements for exchanges or capital requirements for banks. Margin requirements are cash or securities that an investor must set aside as collateral to make sure that he or she can honor a commitment. Capital requirements force banks to maintain a minimum equity-to-debt ratio. In some cases, these requirements may prevent a chain of defaults: A trader who requires high margins is less likely to be affected, should one of its counterparties default. Similarly, a bank with a large capital cushion is less likely to fail, should its deposits with another bank lose value.[6]

In many instances, networks don't just arise spontaneously; they are designed. One example is a joint liability arrangement in which every member of a group is responsible for the others' debts. The Grameen Bank uses such arrangements to make unsecured loans to people in Bangladesh.[7] In this arrangement, if one member of the group defaults, she and other members in her group are denied future loans.[8]

> When we choose between being linked and not being linked, we need to weigh the benefits of better insurance against the potential for the whole group's collapse.

[2] See the article by Albert Kyle and Wei Xiong.

[3] To learn more about the speed with which contagion develops, see the article by Roger Lagunoff and Stacey Schreft.

[4] The argument in the previous paragraph can also be used to show how crises can spread across countries. If, for example, the two stocks were traded in two different countries, political instability in one country could result in price declines of the stocks in both countries.

[5] This point is developed in the article by Nobuhiro Kiyotaki and John Moore. They also show that the crisis may even carry on to the future. In other words, small liquidity problems today can persist over time. The basic idea is that lower levels of investments today may translate to a decline in the value of the firm's assets in the future. This reduces the firm's ability to borrow in the future, leading to a further reduction in investments and a further decline in the value of the firm's assets.

[6] One should be cautious, however, when setting margin requirements. If margins are adjusted daily, as in a futures exchange, temporary liquidity problems may mean that firms do not have enough cash to meet the margin requirements. This by itself may sometimes trigger contagion.

[7] See the book by David Bornstein for more information about Grameen Bank.

[8] One explanation why these loans work is that group members can impose additional penalties on a defaulting member, thereby encouraging her to take more care and pay her loan. This is sometimes referred to as social collateral. An alternative explanation suggested by my own work is that joint liability arrangements induce members of the group to bail out other members who may have difficulties repaying their loans.

Grameen Bank is not a public charity. To make profits, it needs to carefully design the loans. In particular, it may need to come up with answers to questions such as: How many members should form a group? What factors should be taken into account in determining the group's size?[9]

Networks can also arise from the choice of production methods. In the trade credit example, linkages would not arise if each firm produced its own inputs, rather than relying on other firms.[10]

Linkages May Enhance Commitment. When thinking about how to design a network, one factor that should be taken into account is that linkages can affect firms' ability to make commitments.

Companies often enter financial contracts (for example, forwards, futures, options, and swaps) for insurance purposes. This is sometimes referred to as hedging. One of the great benefits of insurance is that it permits the parties involved to undertake risky (but promising) activities efficiently. For example, suppose that I am uncertain about the future profitability of the firm I own. However, I know that it will either face liquidity problems or have more cash than it can use profitably. Suppose also that the same is true of the firm that you own. Both of us would find it profitable to enter insurance contracts that say: "I will give you cash when I have plenty and you have liquidity problems, and you will give me cash when you have plenty and I have liquidity problems."[11] If the uncertainty about future profits resulted from some new, promising project I was considering, the inability to obtain insurance could mean that I would not undertake the project.

In some cases, however, it may be difficult or even impossible to ensure that anyone will actually honor such an agreement. People can walk away from agreements, hiding money or changing accounting figures. Many times you cannot do much about a broken agreement, or it may not be worth your time or money to go to court.

> Firms that have a lot of cash will give cash to firms that face liquidity problems, not because of a formal contractual commitment but because of the threat of contagion.

Another potential problem is that it may be difficult for the contracting parties to ascertain precisely how much cash a firm can actually raise on short notice. Thus, if you entered a contract that says, "I will give you cash when I have plenty and you have liquidity problems," the court would not be able to enforce it. These are all special cases of what economists call lack of commitment — a person cannot commit to pay even if he is able to. Without some method for enforcing commitments, companies simply won't sign such contracts, and everyone will be worse off because of the loss of insurance.

In a recent working paper, I show that linkages can lead firms to honor commitments that no contract could enforce. Firms that have a lot of cash (or a lot of liquid assets) will give cash to firms that face liquidity problems, not because of a formal contractual commitment but because of the threat of contagion. In other words, cash-rich firms are willing to bail out firms with financial problems to make sure that these problems will not spread to them. The idea is simple: If I bail you out, I lose something because I give you cash for free. On the other hand, if I choose not to bail you out, I may lose much more.

Consider, for example, the case in which I rely on you to supply my firm with an essential input. Suppose further that you have liquidity problems while I have extra cash. I can choose one of two options: either bail you out or not bail you out. If I choose to bail you out, I lose some money, say, $1 million, because I am giving you cash that I could invest elsewhere for a higher return. However, if I choose not to bail you out, I may see a decline of, say, $3 million in future revenues because you did not provide me with the essential part. This may even drive me out of business. Obviously, I am better off bailing you out.

Note that when I'm forced to bail you out, I — like any insurer forced to pay a claim — will probably regret the linkage that made the bailout necessary. I may wish that I had spread my business among many input suppliers, even those that charged me more. Remember, however, that the initial supply arrangement was made at a time when neither of us knew who would face liquidity problems and who would have extra cash. If we were both equally

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[9] Networks are also designed in payment systems. See the paper by Xavier Freixas and Bruno Parigi or my working paper.

[10] Alfred Chandler's account of large firms taking over input suppliers and retail distribution in the early 1920s provides an example of a (nonfinancial) network designed to reduce linkages. According to Chandler, these firms became vertically integrated to enhance coordination and to prevent delays that would hold up the chain of production and distribution.

[11] This simple type of insurance contract is seldom observed in real financial markets, but an agreement like this underlies the more complicated contracts we do observe, such as options.

likely to face problems, the mutual exposure created by the exclusive supply arrangement was a good idea for both of us: Each expected the other to provide insurance against the possibility of liquidity problems. In other words, the benefit of being linked is that it leads each of us to bail out the other, just as if we were able to commit to honor formal insurance contracts.

But Linkages Also Promote Contagion. Remember, however, that linkages may lead the whole system to collapse as problems at one firm spread to others. In my working paper I illustrate two general reasons the whole financial network may collapse.

The first reason is obvious: There may not be enough cash to carry out the bailout. For example, suppose that you need $1 million to cover your financial problems. What if I only have half a million dollars today? If we were not linked to one another, my firm would survive while your firm would go bankrupt. But when we are linked to one another, both your firm and mine will go bankrupt.

The second reason, which is not so obvious, is that there may be enough cash to carry out a bailout, but it is concentrated in the hands of very few firms. Suppose, for example, that there are six firms: five that have enough cash to carry out their business and one with significant liquidity problems. Now, take an extreme case and suppose that only one of those five firms has extra cash. If that firm decides to handle the bailout on its own, it will need to spend a lot, say, $5 million. If the firm with extra cash decides not to bail out the troubled firm, it will be able to keep all its money but may lose future revenues of, say, $3 million because of its linkage. In this case, the threat of contagion is not severe enough to compel the healthy firm to carry out the bailout on its own; therefore, all the firms will face the negative consequences of contagion (losing future profits and potentially going out of business). On the other hand, if wealth were spread more evenly among the five healthy firms (for example, if each of the five healthy firms had $1 million to spare), a bailout could occur and contagion would be contained, since the cost of not bailing out the firm would exceed the cost of joining the bailout.

Network Design Involves Tradeoffs. As we can see from the discussion above, when we choose between being linked and not being linked, we need to weigh the benefits of better insurance against the potential for the whole group's collapse. Note that the choice is not necessarily between having everyone linked to everyone else or having no one linked to anyone else. Sometimes the best solution is to create smaller groups of individuals who are linked to one another. In the case of loans made by Grameen Bank, groups usually include five individuals.[12]

THE PROS AND CONS OF BAILOUTS

So far we have seen how contagion can happen (because of linkages among firms and individuals) and how the threat of contagion can induce voluntary bailouts that may prevent contagion. (That is, these same linkages enhance commitment.) In some cases, a bailout can succeed only if many firms participate because any one firm may not have enough cash for the bailout or because one firm alone doesn't have the incentive to bail out another because the cost to the firm is too high.

Participation by many firms raises a new issue: All firms might benefit if they could coordinate to bail out a single firm in trouble, but acting in concert can be difficult without some formal organization. This may be especially true if the number of firms that need to coordinate their actions is large. One reason coordination may be unusually difficult is "free-riding." Each firm would like the other firms to do the work. In other words, if other firms participate, my participation may not be crucial for the success of a bailout. So I may decide to save money and not participate. But if many firms reason this way, coordination fails and the bailout never takes place.

An Example of Successful Coordination. Both the difficulties of coordination and the availability of coordinating mechanisms are well illustrated by the private-sector bailout of Long Term Capital Management (LTCM), in which the Federal Reserve Bank of New York acted as coordinator. LTCM, a prominent hedge fund, suffered large losses and was on the verge of bankruptcy after Russia declared a debt moratorium on August 17, 1998. Throughout September, LTCM tried to initiate an infusion of funds from its bankers. Coordination was necessary because any individual bank that attempted to bail out LTCM would simply be reducing the other banks' losses without providing enough funds to solve the problem. One problem that made coordination difficult was that different banks had different levels of exposure to LTCM. Herbert Allison, then president of Merrill Lynch, was one of the leaders in the effort to organize the bailout. After analyzing the plan, he advised the New York Fed's Peter Fisher that "the only way to get the banks together was for the Fed to call them and offer to hold a meeting."[13]

[12] In my working paper I present examples in which the group size that best balances the benefits of greater commitment and the problems of increased risk of system failures is small (say, three), for small economies (of, say, 12 people), large economies (of, say, 12 billion people), or even infinitely large economies.

[13] As reported in Roger Lowenstein's book, p. 198.

On September 22, Peter Fisher contacted the 16 banks that were the largest counterparties to LTCM and organized an emergency meeting at the New York Fed. On September 28, a consortium of 14 commercial and investment banks agreed to bail out LTCM. The total amount was $3.6 billion, and the consortium of bankers contributed all the money; the government provided no funds or guarantees. Some banks (those with high exposure) contributed $300 million each while other banks (those with low exposure) contributed $100 million each. Two banks (Citicorp and Bear Stearns) declined to participate.

On October 1, 1998, in his testimony before the House Committee on Banking and Financial Services, Federal Reserve Chairman Alan Greenspan said: "Officials of the Federal Reserve Bank of New York facilitated discussions in which the private parties arrived at an agreement that both served their mutual self-interest and avoided possible serious market dislocations." He also said, "The Federal Reserve provided its good offices to LTCM's creditors, not to protect LTCM's investors, creditors, or managers from loss but to avoid the distortions to market processes caused by a fire-sale liquidation and the consequent spreading of those distortions through contagion."

Bailouts May Undermine Incentives to Be Careful. During that same testimony, Chairman Greenspan also acknowledged the problem of moral hazard: "Of course, any time that there is public involvement that softens the blow of private-sector losses — even as obliquely as in this episode — the issue of moral hazard arises." What does *moral hazard* mean? Moral hazard usually refers to high-risk activities in which an insured person might choose to engage, *but that the insurer cannot monitor*. For example, if you have homeowners insurance, you may be less careful about locking the doors when you go out or you might leave a fire unattended in your fireplace. Similarly, if you thought that you would always be bailed out, you might choose to take excessive risks, that is, risks that would not be sanctioned by an insurer.

Does this mean that we should try to avoid bailouts at all costs? The answer is not necessarily. That would be like saying that we should not be allowed to get homeowners insurance. However, incentives such as those created by moral hazard are another factor that must be taken into account when designing financial networks.

SUMMARY

In this article, we have seen how the ways in which firms are linked to one another may trigger contagion. We discussed the issue of an optimal design for networks and showed that we need to be careful not to fall into traps. Things may not be as simple as they first appear. The negative effects of contagion may lead us to believe that we should limit exposure between financial institutions.

We have seen, however, that in some cases such exposure may be good for everyone despite and because of the threat of contagion: The threat of contagion enhances commitment. We have also seen how bailouts may prevent contagion, but they may require a coordinator to bring them to fruition. Like any form of insurance, bailouts may create a moral hazard, but that does not necessarily mean we should avoid them at all costs. We should always think about the tradeoffs.

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